



# Los Alamos researchers develop platform to study subsurface reservoir conditions

March 7, 2016

Los Alamos researchers have developed a high pressure and temperature microfluidic experimental system to investigate pore-scale fluid flow and transport within geo-materials encountered in subsurface energy resource applications. The experiments can be conducted with brine, oil, and carbon dioxide (CO<sub>2</sub>) at temperatures and pressures similar to naturally occurring reservoirs. The information gained from this system could enable development of future subsurface energy resource technologies while understanding and mitigating the environmental consequences. The journal [Lab on a Chip](#) published the research.

## Significance of the research

As the population increases, the demand for global energy continues to increase. By 2030, the demand for all energy types (nuclear, renewable, natural gas, coal, and oil) is expected to more than double. This increasing demand for energy around the globe requires a better understanding of subsurface energy resources and their associated environmental issues. In the U.S. alone, the subsurface currently provides more than 80% of total energy needs.

Subsurface energy operations are often viewed as reservoir-scale problems (ranging from tens to hundreds of kilometers); however, the underlying fluid flow and transport processes occur within the rock's nano- to millimeter-sized pores and fractures. Technology to control fluid flow (e.g., water, brine, oil, and gas) within the rock's micropores and fractures underlies all subsurface energy applications. Examples of these applications include conventional and unconventional oil and gas development, enhanced oil recovery, geothermal energy, carbon dioxide sequestration for environmental impact mitigation, and nuclear waste repositories.

The Lab team created a unique high pressure and temperature microfluidic experimental system for direct observations of flow and transport within geo-material micromodels at reservoir conditions. This new experimental system is an improvement over other current systems, which have limited applicability due to unrealistic operating conditions, the use of engineered material (rather than rock), and the lack of realistic pore or fracture geometries.

## Research achievements

The investigators developed a novel micromodel fabrication method. It uses 3-D tomography images of real, complex pore or fracture patterns as micromodel templates to better represent the pore space and fracture geometries expected in subsurface formations. A laser system designed and constructed at the Lab's Center for Integrated Nanotechnologies (CINT) etched features down to 10 microns in thin sections of rock. The team loaded the micromodels into pressure vessels for experiments using brine, oil, and CO<sub>2</sub> at temperatures and pressures similar to naturally occurring reservoirs. Characterization of supercritical CO<sub>2</sub> (scCO<sub>2</sub>) displacing water in fracture networks is essential for predicting the performance of CO<sub>2</sub> sequestration within a given rock. The team showed that injected scCO<sub>2</sub> quickly creates a narrow path within a fracture and continues along that path, leaving a significant amount of water in the fracture. Fracture surface roughness likely causes the localized displacement path. The displacement efficiency is greatly reduced in this fracture compared with that observed in straight fractures. This experiment demonstrates the complexity of immiscible displacement in realistic rock fractures, and the result illustrates the value of the new experimental platform for more realistic representations of rock geometries and properties.

## Research team

Mark L. Porter of LANL's Earth System Observations group led the team, which included Joaquin Jiménez-Martínez and J. William Carey, Hari S. Viswanathan of the Lab's Subsurface Flow and Transport group, and Ricardo Martínez and Quinn McCulloch of LANL's Center for Integrated Nanotechnologies.

DOE Fossil Energy and the Laboratory Directed Research and Development (LDRD) programs funded different aspects of the work. The DOE Office of Science sponsors the Center for Integrated Nanotechnologies (CINT), and Apache Corporation provided in-kind services. The research supports the Lab's Energy Security mission area and the Materials for the Future and Science of Signatures science pillars through the development of a microfluidic platform to model subsurface energy resource applications.

Caption for image below: Supercritical CO<sub>2</sub> (white) displacing n-decane (black) and brine (blue). The grey circles are the solid phase and the color gradient from yellow (high) to red (low) represents the concentration of supercritical CO<sub>2</sub> in oil.

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